

Introduced and native grass-derived smoke effects on *Cymbopogon obtectus* germination

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Abstract. Introduced grasses, such as buffel, alter the dynamics of grassy ecosystems by replacing native species and influencing recruitment. Several different smoke-derived chemicals are separately responsible for the promotion and inhibition of germination of various plant species. We tested whether smoke derived from the introduced buffel grass (*Cenchrus ciliaris*) produced the same density of germination as provided by smoke derived from a native spinifex grass (*Triodia brizoides*). Smoke from both spinifex and buffel grass significantly enhanced the germination of a native lemon grass (*Cymbopogon obtectus*) in comparison to untreated seed, reflecting the significant role of fire in woodlands across northern Australia. This is the first record of smoke-promoted germination in a species of *Cymbopogon*. However, smoke from the exotic buffel grass provided the same level of germination as that from the native spinifex, suggesting similarity in smoke chemicals involved. Further research is required to test the effect of buffel smoke on the germination of other species and whether exotics such as buffel grass provide the same temperature profile in the topsoil as does spinifex, and therefore equivalent germination cues to heat-shock responsive native plants.

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Introduction

Fire stimulates the germination of many plant species across the globe, through a range of dormancy-breaking mechanisms. These include the brief exposure to heat shock or the chemicals in smoke, and the temporary removal of shade (Bell *et al.* 1993; Clarke *et al.* 2000; Williams *et al.* 2005a, 2005b).

The influence of smoke in promoting seed germination is widespread across a large number of plant families throughout the world (de Lange and Boucher 1990; Baxter *et al.* 1994; Dixon *et al.* 1995; Keeley and Fotheringham 1998). It has even been observed in South African and European species not typically subject to fires (Pierce *et al.* 1995; Mojzes and Kalapos 2014). This ubiquity suggests a consistent evolutionary origin to the chemical trigger present in the smoke. However, although the smoke produced from a wide range of species appears to have a common stimulating effect, exceptions have been found where the germination of a species is promoted by the smoke of one species but not another (Baxter *et al.* 1995).

Invasive species pose a significant threat to many ecosystems. Many invasive grasses alter fire regimes through their effect on fuel loads (Rossiter *et al.* 2003). Invasive grasses can have a negative impact on the germination of native species. For

example, leaf and root leachates of buffel grass (*Cenchrus ciliaris*), native to Africa and southern Asia, have been shown to inhibit the germination of some legumes native to Texas (Fulbright and Fulbright 1990). Although the similarity in chemical constituents of smoke among plant species has been demonstrated (Flematti *et al.* 2004), it is possible that some chemical aspect of the smoke derived from invasive species may not provide the same germination stimulation to local plants as does the smoke from species native to that ecosystem.

Buffel grass has invaded extensive areas of Australian rangelands, outcompeting native grasses and altering fuel loads (Butler and Fairfax 2003; Eyre *et al.* 2009). Species diversity in buffel grass-invaded woodlands is lower than in those dominated by native grasses (Jackson 2005). This appears to be due to its dense smothering biomass, although buffel grass may also have an impact on Australian native plant germination. Although fires fuelled by buffel grass promote the germination of some plants, e.g. the exotic *Parthenium hysterophorus* (Butler and Fairfax 2003), it is unknown whether buffel grass stimulates the same density of seedlings that has been demonstrated in spinifex-fuelled fires (Williams *et al.* 2007). Spinifex (*Triodia* species) is a resinous

grass that dominates arid and semiarid Australia and is an example of dominant grass that is being replaced by buffel grass. Because of their resin, the fires fuelled by spinifex are often intense and produce a particularly dark smoke (Burrows *et al.* 1991).

Several species in the spinifex woodlands of northern Australia are known to have smoke-promoted germination, including one of the common spinifex grasses, *Triodia pungens* (Gamage *et al.* 2014). In the present study, we compared the effect of smoke derived from the non-native buffel grass with smoke from the native spinifex, *Triodia brizoides*, on seed germination density of the native perennial lemon grass, *Cymbopogon oblectus*.

Materials and methods

Seeds from *C. oblectus* were collected on the 9 and 10 April 2014, from more than 10 different plants in *Eucalyptus leucophloia* woodland near Mount Isa, north-western Queensland (−20.64°S, 139.493°E). The *C. oblectus* seeds were mixed and then sorted into batches of 100 seeds. Three replicate batches of 100 seeds were randomly allocated into one of the following three treatments:

- (1) control,
- (2) 30-min exposure to buffel grass (*Cenchrus ciliaris*) smoke, and
- (3) 30-min exposure to spinifex (*Triodia brizoides*) smoke.

The control treatment involved spreading the 100 seeds of each replicate across a seedling tray (35 cm × 30 cm × 5 cm) with potting mix, covering the seeds with ~1 cm of potting mix and placing in a shade house for germination.

Smoke was produced through combustion of buffel grass or spinifex samples. Fresh leaves and stems were collected from multiple plants across a 2-km stretch of woodland at the same location that the seeds of *C. oblectus* were collected.

The production of the separate buffel grass and spinifex smoke treatments followed the method described in Dixon *et al.* (1995). Smoke was produced in a 200-L metal drum filled with smouldering grass (either buffel or spinifex) collected from the Mount Isa site. Air was pumped into the bottom of the drum and out the top to force the smoke through a 3-m by 5-cm-diameter metal pipe. The 3-m pipe was covered with wet rags, which allowed the smoke to cool, before entering a plastic tent, in which the seeds were placed on aluminium trays. Smoke was pumped into the tent for 30 min before the seeds were removed for incubation in a shade house. Each replicate batch of 100 *C. oblectus* seeds was treated with separate smoke treatments to ensure independent replicates. That is, in total, there were three separate 30-min-long exposures to buffel grass smoke and three separate 30-min-long exposures to spinifex smoke, treating a total of six batches of 100 *C. oblectus* seeds. However, the same drum was used to produce smoke.

The seeds were incubated in a shade house with daily watering at the Atherton base of CSIRO in north-eastern Queensland from the day of smoke treatments, 24 April to 21 July 2014, i.e. 13 weeks, at which point germination had ceased for several weeks.

A one-factor ANOVA was used to assess the significance of differences in percentage germination among treatments. Scheffe's *post hoc* test was used to determine significant differences among treatments and a Cochran's test was used to ensure homogeneity of variance (Underwood 1997).

Results

The percentage germination of *C. oblectus* seeds in the control treatment was significantly lower than in both of the smoke treatments ($F_{2,6}=31.441$, $P<0.001$; Fig. 1). There was no significant difference between the percentage germination of *C. oblectus* seeds exposed to buffel grass and that of seeds exposed to spinifex-derived smoke. In fact, the mean germination was almost identical from both treatments (Fig. 1).

Discussion

The promotion of *C. oblectus* germination by smoke reflects its population persistence in a flammable community and is similar to that of many other Australian native grasses, such as the spear grasses, *Heteropogon contortus* and *H. triticeus* (Campbell *et al.* 1996; Clarke *et al.* 2000; Williams *et al.* 2005a). However, this is the first record of a species of *Cymbopogon* to show a significant germination response to smoke. In contrast to *C. oblectus*, no smoke-enhanced germination has been detected in multiple assessments of the related *C. refractus* in southern Australia (Read and Bellairs 1999; Clarke and French 2005) or of *C. schoenanthus* from Africa (Dayamba *et al.* 2010). This may reflect the typical fire regime of occasional intense spinifex fires in the ecosystem where the test population of *C. oblectus* grows. However, *C. oblectus* is widespread and grows in a range of ecosystems, so that populations of *C. oblectus* from different ecosystems may respond differently to smoke.

It is clear from the present trial that the chemical stimulant that triggers germination of *C. oblectus* is present in equal measure in the exotic buffel grass and the local spinifex. However, further research is needed to evaluate the effect of buffel grass smoke on the germination of other species. An examination of the role of smoke on seed germination of *C. oblectus* populations from different ecosystems, especially

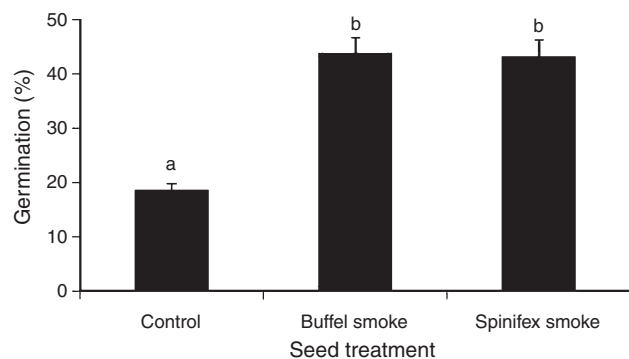


Fig. 1. The mean percentage germination of lemon grass, *Cymbopogon oblectus*, seeds exposed to three treatments. Error bars are one standard error of the mean. Columns with the same lower-case letter are not significantly different at $P=0.05$.

less flammable ecosystems, would also provide an interesting assessment of the role of smoke derived from different fuels. A few chemical compounds from plant-derived smoke, karrikinolide and glyconitrile, have been identified as triggering germination in different species (Flematti *et al.* 2004, 2009, 2011; van Staden *et al.* 2004; Downes *et al.* 2010, 2013). Therefore, the complex role of smoke in germination ecology is yet to be fully resolved and it remains possible that smoke derived from exotic plants may not promote the same level of germination as does smoke from plants native to a particular ecosystem.

Further evaluation is also required to test whether buffel-fuelled fires promote the same density of native seedlings in the field. There may be differences in temperature penetration into the topsoil, and subsequent germination of heat-shock responsive species, between buffel grass and spinifex fires.

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